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Procedia Manufacturing 2 (2015) 6 – 10

Procedia MANUFACTURING

2nd International Materials, Industrial, and Manufacturing Engineering Conference, MIMEC2015, 4-6 February 2015, Bali Indonesia

Production line analysis via value stream mapping: a lean manufacturing process of color industry

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Abstract

Lean Manufacturing (LM) is a business strategy that was developed in Japan. The main role of lean manufacturing is to determine as well as to eliminate the waste. Companies implement LM to keep their competitiveness over their competitors by improving the manufacturing system's productivity and quality enhancement of the product. The goal of this paper is to apply one of the most significant lean manufacturing techniques called Value Stream Mapping (VSM) to improve the production line of a color industry as a case of study. To achieve this goal, lean fundamental principles was implemented to construct VSM for identification and elimination of wastes by using team formation, product selection, conceptual design, and time-frame formulation through takt time calculation. Based on the future VSM, final results showed that by implementing some lean thinking techniques, Production Lead-time (PLT) decreased from 8.5 days to 6 days, and the value added time decreased from 68 minutes to 37 minutes.

Keywords: Lean Manufacturing;Value Stream Mapping; Waste; Color Industry

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doi:10.1016/j.promfg.2015.07.002

1. Introduction

Firm's efficiency and competitiveness are two important challenges in today's global market that have motivated many manufacturing firms to plan novel manufacturing management strategies [1]. The most critical issue faced by manufacturers today is how to deliver their products or materials quickly at low cost and good quality [2]. Several methods and approaches exist such as computer simulation, statistical analysis, and lean tools for improving the efficiency and productivity by determining the best combination of resources in production lines, construction process, energy, services and supply chains [3-5]. One of the effective management approaches is Lean Manufacturing (LM) system that has taken by many manufacturing firms in different forms and names. The concept of LM was proposed by a Japanese automotive company, Toyota, during 1950's which was famously known as Toyota Production System (TPS). The first goal of TPS was to improve productivity as well as to decrease the cost by eliminating waste or non-value added activities [6,7]. Lean manufacturing is one of the important steps that many major businesses in the United States have been attempting to implement in order to sustain their competitiveness in a rising global market [8]. Main goal of this approach is on cost reduction by decreasing non-value activities. Based on the Toyota Production System, lean manufacturing tools and techniques such as just-in-time, cellular manufacturing, total productive maintenance, single-minute exchange of dies, and production smoothing have been consistently applied in different discrete manufacturing systems involving automotive, electronics [9]. These improvements based on cost reduction are obtained by eliminating the wastes related to all activities done to deliver an order to a customer [10]. Wastes include all activities that used resources by imposing cost to the product, but do not have a significant value on the customer. There are five steps to implement lean thinking in a company: 1) define value from the perspective of the customer, 2) determine the value streams, 3) Achieve Flow, 4) Schedule production using Pull, and 5) seek perfection through continuous improvement [11]. Value stream includes all the specific activities (both value-added and non-value-added) needed to bring a particular product by implementing three important management skills of any business that are problem solving, information management and physical transformation [10]. Lean manufacturing applied tools and approaches such as Just-In-Time (JIT), Total Productive Maintenance (TPM), Cellular Manufacturing and 5S [12]. Moreover, lean accounting, as a coordinated approach, along with lean thinking provides administrators with reliable, accurate and timely information for decision-making. Hence implementation and control, of the lean system as new approach becomes for strategic management approach [13]. The goal of this paper is to apply one of the most significant lean manufacturing techniques called Value Stream Mapping (VSM) to improve the production line of a color industry as a case of study.

2. Materials and Methods

VSM includes a set of all activates (value added as well as non-value added) that are essential to bring a product through the main flows, starting with raw material, and ending with the customer [10]. The main goal of VSM is to find different types of wastes and trying to eliminate them. The first step is to select a specific product or product family as the target for improvement. The second step is that to develop a current state map that is mainly a snapshot capturing how processes are currently being done. The third step is to draw the future state map that is a picture of how the production process should be done after the wastes and inefficiencies have been removed. The future state map is created based on answering a collection of questions on topics relevant to efficiency as well as implementing technical issues related to the application of lean techniques. Finally, the suggested map is applied as a basis for making essential changes to the system. A brief explanation of the some various available lean methods and techniques are as follows: Cellular Manufacturing: systematize the whole process for a particular product or related products into a set or cell that it includes all the needed equipment, machines, and operators. Just-in Time: a method whereby a client's request is treated such that the request is sent out backward from the last assembly of unprocessed material, thus ''pulling'' all the needed resources as at when needed. Kanban: the marking system for developing JIT production where by a visual signal helps flow by 'pulling' product through the process as required by the customer. Single minute exchange of dies (SMED): a changeover reduction technique. 5S: Concentrates on efficient workplace organization and standardized work events. This is a housekeeping method which entrusted control to the shop floor.

3. Case Study

A Color Factory is selected as a case study in this paper. This company is a leading manufacturer of industrial and building paint. Since the products are produced according to the customer order, the layout of the factory is based on job shop system. The production line of different products (such as industrial paint, plastic paint, stone putty, and thinner) is located separately as well as the packaging section and laboratory. Having conducted the simulation, we found out that the production line of paint paste is a bottleneck. In addition, there are lots of reworks during the production process because of poor production control. Moreover, parts have to be transferred from machine to machine to complete the required operations. This situation decreases labor productivity and increases material handling cost. Therefore, these causes delay of orders, lower quality, less labor productivity, more waiting times, large Work in progress (WIP), longer material movement. To overcome these problems there is a need to identify the key areas, which are producing wastes, and to identify bottleneck operations. The following information is related to production line: Working shift per day = 1, Working hours per shift = 8 hours, Available time per shift = 480 minutes, Tea break per shift = 2breaks * 10 minutes = 20 minutes, Lunch break per shift = 60 minutes, Down time per shift = 0, Total daily demand=40.

4. Result and Discussion

4.1. VSM: Current State Map

Whole information about the present state map was gathered based on the method suggested by Rother and Shook [10]. In the issue of the material flow data collection began in the distribution section and also worked rearward for the stamping development, collecting image data like catalogue levels earlier than beginning every process, cycle times (CTs) process, quantity of employees, and convert (CO) times. Figure 1 demonstrated the present position map which was drawn. In this figure the map's small boxes describe the progression and the number of the boxes is the amount of workers in every processes. In addition, every process has a data box under that includes the CT process, the numeral of shifts, machine reliability (MR), and the CO time. All of the processing and installing times are according to the middling of past data. The timeline in the underside of the present situation map is shown in Figure 1 that there are two elements. The first element is about the waiting time of production in days which is gained by adding the number of lead-time from every inventory triangle earlier than every process. Therefore, the time of each inventory triangle is computed by separating the inventory numbers into the everyday customer needs. The totality lead time is approximately 8.5 days. The second component of the timeline is the value-added or processing time which is approximately 68 minutes. This period is computed by summing the processing time for every process in the value flow. The CT for every process is the average CT that was found out by using real data in the firm.

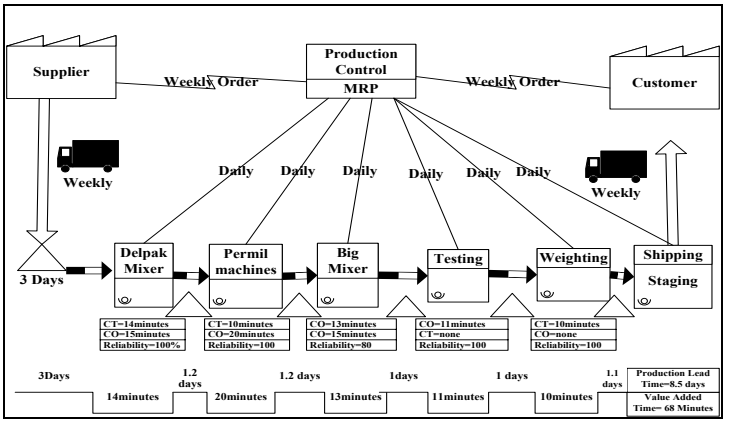

Fig. 1. Current VSM

4.2. VSM: Takt Time

The Takt time is the demand rate and consequently the time between completions of each product off of the production line. To calculate the takt time, the following formula is used [1]:

$$\text{Takt time} = \frac{Available\ minutes\ for\ production}{Required\ unites\ of\ production},\quad \text{Takt time} = \frac{480\ \text{minutes}}{40} = 12\ \text{Minutes}$$

Takt Time plays a leading role in manufacturing systems. Many factories run this without knowing what it is such as what those industrial units lose or how things are going minute by minute as a fine-grained sense [11]. It is an expression of consumer requirements that normalized and levelled over the prefer time to produce. Takt time helps to make easy the ability of calculation in a difficult flow. In addition, the necessary speeds of machines and other capital tools are determined. By using this, the minimum batch sizes are estimated when there are changeovers involved.

4.3. VSM: Future State Map

In this case following equipment was designed to implement the future map.

Balance the Line: First a value steam is needed for realizing there is a line. One of the issues that cause to face with wait between the processes is queuing effects. It caused to create the bottleneck in an uncontrolled process by collecting work. Therefore, in order to decrease all these waiting, following techniques are suggested:

Remove bottlenecks: Bottlenecks are identified as tasks to take more time for doing and/or to have fewer assets that accessible to them than the take a break of the process. Regarding the current VSM, it is obvious that the big mixer and delpak mixer stations have the most cycle time with 14 and 13 minutes respectively that makes WIP before the station. Continuous flow is applied for producing products using a batch size of one. This is a very efficient means of production since no inventory is created between process steps as well as it eliminates many forms of waste. In addition, 5S principles were implemented to eliminate waste that results from a poorly organized work area (e.g. wasting time looking for a tool). Following that, Kanban method was provided to eliminate waste from inventory and overproduction. It eliminates the need for physical inventories (instead relying on signal cards to indicate when more goods need to be ordered). Figure 2 shows the future state of value stream map based on the improvements.

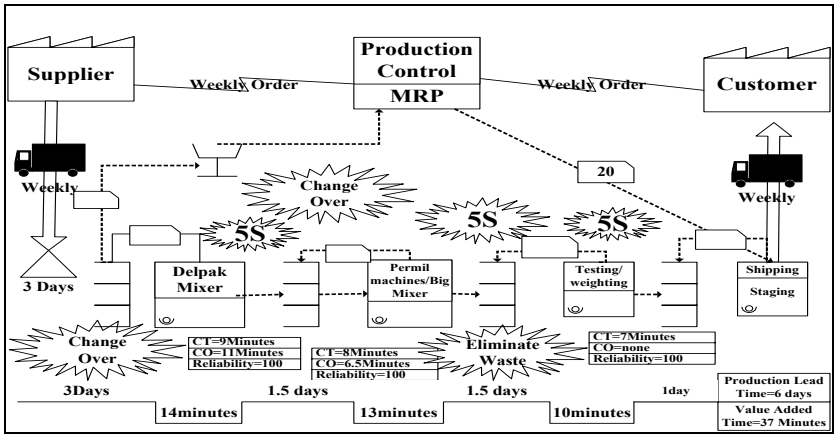

Fig. 2. Future VSM

4.4 Discussion

The main goal of this paper was to develop a Value Stream Mapping (VSM), which is becoming a useful tool for implementing lean manufacturing in actual production settings. The results are presented in the form of current and

future process mapping and improvement is shown in the reduction in valued added time and production lead time. In the future state map, the permil machines and big mixer as well as testing and weighting units were combined to reduce non-value added time during processes. Implementation of 5s techniques, Kanban method, continuous flow, result in effective organization of the workplace, reduction of work's environment, elimination of losses connected with failures and breaks, improvement of the quality and safety of work. Supermarkets are placed between processes to reduce inventory wastages during process and to turn process from build to stock to make to order. The information and communication flow between processing lines improved by scheduling pacemaker in the process as well process turned from push to pull by Kanban system. On this research we have made some sizeable improvements. Production Lead-time (PLT) has gone from 8.5 days to 6 days, and the value added time decrease from 68 minutes to 37 minutes (Figure 3).

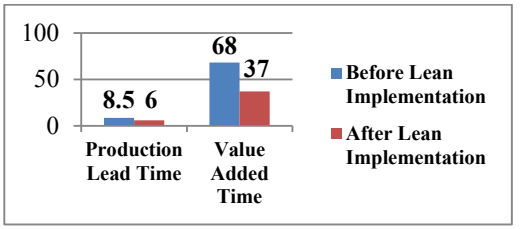

Fig. 3. Current state vs. future state

5. Conclusion

The goal of this paper was to develop a value stream map for a color industry to determine and eliminate the wastes that did not add value to the final product. It also aimed to reducing lead time and value added time to increase the total throughput. Based on future VSM, final result showed that by implementing some lean manufacturing techniques such as 5S, Kanban method, Kaizen and so on Production Lead-time (PLT) decreased from 8.5 days to 6 days, and the value added time decreased from 68 minutes to 37 minutes. More investigation can be done by combining the VSM and computer simulation to evaluate more effective factors that have a significant effect on the total throughput based on decreasing wastes.

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